Evaluation of Ecosystem Metabolism in the Reservoirs

Yuening PENG[1], Keisuke NAKAYAMA[1], Hibiki YONEDA[1], Hiroyuki MAETA[1], Satoshi WATANABE[2], Masaomi KIMURA[3] and Katsuaki KOMAI[4]

[1]Dept of Engineering, Kobe University, Hyogo 657-8501, Japan.
[2] Dept of Social and Cultural Studies, Kyushu University, Fukuoka 819-0395, Japan.
[3] Faculty of Agriculture, Kindai University, Nara 631-8505, Japan.
[4] Dept of Engineering, Kitami Institute of Technology, Hokkaido 090-8507, Japan.

1. Introduction

Against the backdrop of global warming, "Freshwater Carbon" has received increasing attention. Recent studies have shown that the potential for carbon capture and storage in freshwater carbon is enormous compared to that in blue carbon ecosystems. [1)] However, there is little research worldwide on the factors affecting carbon dioxide absorption and release. In addition, the method for quantitatively estimating carbon dioxide absorption has not yet been established. Furthermore, research on the relationship among pH, dissolved oxygen (DO), and photosynthetic activity has not been sufficiently conducted. The activity of phytoplankton and aquatic plants is referred to as "lake metabolism," and Odum[2)] proposed a method for estimating gross primary production (GPP), ecosystem respiration (ER), and net ecosystem production (NEP) using hourly changes in DO. Hoellein et al. demonstrated that GPP, ER, and NEP tend to increase as lake size increases; however, no study has been conducted using pH—which Sakaguchi et al. identified as an important factor—as an indicator.

2. Methods

In this study, we conducted observations of water temperature, pH, and dissolved oxygen (DO) over several months from spring to autumn in three reservoirs located in Saijo City, Ehime Prefecture. We examined changes in ecosystem respiration (ER) and the rate of DO change due to photosynthesis, referred to as ecosystem photosynthesis (EP), and then analysed the effects of pH on these parameters. Furthermore, short-term observations were conducted in April, when aquatic plant activity peaks, to investigate the relationships among ER, EP, and the partial pressure of carbon dioxide in the water, as well as the relationships among lake metabolism, pH, DO, and the partial pressure of carbon dioxide in the water.

3. Result

The observation results indicated that when pH increases due to photosynthesis by aquatic

plants, DO also increases. In addition, correlation analysis between pH and DO showed that the Yamanokami Reservoir did not exhibit a clear relationship due to inactive photosynthesis, whereas the Shiode Reservoir yielded the expected result. The rate at which DO increases as pH rises can be divided into two stages.

The absolute value of ER in the Shiode Reservoir is larger than that in the Yamanokami Reservoir. In the Shiode Reservoir, in addition to the decomposition of organic matter, the respiratory activity of aquatic plants results in greater consumption of DO. Similar to ER, EP in the Shiode Reservoir is also larger than that in the Yamanokami Reservoir. This is because, due to the presence of aquatic plants and phytoplankton in the Shiode Reservoir, more DO is produced through photosynthesis. The relationship between pH and ER/EP showed that the effect of pH on ER was negligible. On the other hand, although EP in the Shiode Reservoir fluctuated significantly, it generally increased with rising pH.

The short-term observation showed that pH and DO decreased at night and increased during the day. This indicated that CO_2 was absorbed not only from the water but also from the atmosphere. It can also be seen that EP was larger in reservoirs where photosynthesis was active.

4. Conclusion

Observations of three reservoirs revealed a positive correlation between dissolved oxygen (DO) and pH in reservoirs with active photosynthesis. Since pH is an important indicator of aquatic metabolism, EP increased as pH rose, whereas ER showed no correlation with pH. Therefore, it can be concluded that algae and phytoplankton in the reservoirs absorb carbon dioxide from the atmosphere through photosynthesis, resulting in EP being higher than ER, and that they are capable of sequestering the carbon corresponding to this difference. We intend to clarify the relationship among EP, ER, and carbon uptake in future studies.

References

1) Nagatomo, K., Nakayama, K., Komai, K., Matsumoto, H., Watanabe, K., Kubo, A., Tada, K., Maruya, Y., Yajima, K., Tsai, J.W., Lin, H.C., Vilas, M.P. and Hipsey, M.R.: A spatially integrated dissolved inorganic carbon (SiDIC) model for aquatic ecosystems considering submerged vegetation, *Journal of Geophysical Research - Biogeosciences*, Vol.128(2), e2022JG007032, 2023.

2) Odum, H.T.: Primary production in flowing waters1, *Limnology and Oceanography*, Vol.1, No.2, pp. 102–117, 1956